urn:nbn:de:gbv:ilm1-2011imeko-064:8

Joint International IMEKO TC1+ TC7+ TC13 Symposium
August 31st – September 2nd, 2011, Jena, Germany
urn:nbn:de:gbv:ilm1-2011imeko:2

THE QUALITY CONTROL PARAMETERS OF THE MEDICAL RADIOLOGICAL EQUIPMENT

Bercea Sorin, Cenusa Constantin and Celarel Aurelia

Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH Bucharest), Bucharest, Romania

Abstract – The safety of the patients which are submitted to radiological medical investigations is a very important aspect of the use of the ionizing radiation in the diagnosis of the diseases. The irradiation of the patient during a medical radiological procedure strongly depends not only the medical aspects, but, mainly, on the radiological characteristics of the equipment. This is why this paper deals with the quality control parameters of the medical radiological equipment and with the methods for the measurement of these parameters.

Keywords: X-ray, radiological equipment, non-invasive measurement

1. INTRODUCTION

During the last years, the medical investigations are using more and more the X-ray equipments, due to their height performances in the diagnosis of many diseases. The main types of the X-ray equipments involved these investigations are:

- The X-ray equipment for classical radiology (radiography and radioscopy);
- The computer-tomography (TC)

But, all the investigations using the equipments lead to the irradiation of the patient. This is why, one of the most important precautions that the radiologists must take into account, is to reduce as much as possible the irradiation of the patient, without affecting the quality of the investigations results. The meeting of this requirement is mainly influenced by the quality of the radiological equipment. For this reason, special requirements concerning the medical X-ray equipment were issued by the specialised international organisation, as IAEA and IEC [1], [2]. In Romania, these requirements are implemented by the National Commission for the Control of the Nuclear Activities (CNCAN). The Collective of Radiation Metrology, Testing and Dosimetry of the "Horia Hulubei" National Institute of Research and Development for Physics and Nuclear Engineering (IFIN-HH), as accredited laboratory for testing, has also as main activity to identify the relevant parameters of the medical X-ray equipment and to elaborate adequate methods for measuring these parameters.

2. THE QUALITY CONTROL PARAMETERS.

The most important quality control parameters of a classical medical radiological equipment can be classified in two categories:

- Electrical parameters (the peak voltage-kVp, the anodic current-mA);
- Radiological parameters (the half-value layer-HVL, the radiation quality – Q, the absorbed dose rate-D or the dose equivalent rate-H, in a given geometry, in the X-ray beam).

We underline the following aspects regarding the influence of the electrical parameters on the radiological parameters:

- The peak voltage, together with the total filtration are determining the average energy of the photons from the X-ray beam, and so, the quality of the radiation;
- The anodic current determines to absorbed dose rate in the X-ray beam (in a given geometry).

3. MEATHODS FOR THE MEASUREMENT OF THE QUALITY CONTROL

There are several methods for the measurement of these quality control parameters; the main two types of methods are:

- the invasive methods;
- the non-invasive methods.

The invasive methods involve the direct measurement of the electrical parameters, by introducing an electrical measuring instrument in the electrical circuits of the X-ray generator; in this way, according the laws of the electrical circuits, the total impedance of the circuit is modified and, consequently, the actual values of the electrical quantities can be affected.

The other class of measuring methods are the non-invasive methods. These methods are based on the effects of the X-ray on the solid state detectors. These effects allow the indirect measurement of the electrical parameters without affecting the impedance of the X-ray machine's circuitry, and so, the measured values of the electrical quantities are not affected according to the laws of the electric circuits. The parameters which can be measured by non-invasive methods are:

- the high voltage applied to the X-ray tube, from the energy of the emitted photons;
- the tube current, from the flux of the photons reaching the detector of the measuring instrument;
- the inherent and the total filtration, and so, the quality of the radiation, from the energy of the photons by comparing the effects on two detectors with different filtration of the radiation; the total filtration can lead to the average energy of the photons, expressed by HVL (the Half-Value Layer);
- the absorbed dose rate in the X-ray beam, due to the fact that the intensity of the effects depends on the energy released by the photons in the detector material.

In this paper we present the non-invasive methods and the results of the measurement of these quantities: the measuring instrument which we used for the measurements is a BARRACUDA [3]. The traceability of the measurements performed with this instrument is assured by the calibration of the instrument at PTB-Germany.

In the same time, we used this instrument to calibrate our X-ray equipment, in order to use it for the calibration of the field instruments used in Romania to check the medical X-ray equipments.

So, we present in the next paragraph some results of the measurements done in parallel with our standard and another measuring instrument (DIAVOLT).

TABLE I.

Total filtration (mm Al)	Quantity	Measuring unit	BARRACUDA	DIAVOLT
	kVp	kV	39.93±0.058	41.95±0.74
	D	µGy	727.03±0.95	711.3±0.70
	t	ms	489.06±0.51	499.2±0.29
3.5	kVp	kV	60.09±0.017	60.63±0.06
	D	µGy	2098.33±2.52	2197.6±3.8
	t	ms	499.5±0.25	500±0.97
3.5	kVp	kV	79.48±0.04	80.83±0.06
	D	µGy	3818.33±2.5	3965 ±1.59
	t	ms	499.5±0.25	500.2±0.17
2.5	kVp	kV	99.82±0.55	99.10±0.62
	D	µGy	5862±3.46	6021± 4.72
	t	ms	499.83±0.29	500.5±0.17
2.5	kVp	kV	122.5±0.064	119.2±0.06
	D	µGy	8536±5.26	8651 ±3.51
	t	ms	639.6±0.12	640.3±0.17

CONCLUSION

As we have already stated, is very important to now the actual values of the electrical and radiological characteristic quantities of radiological X-ray equipment.

The non-invasive methods for measuring these characteristics an important for two aspects:

a) they allow an accurate and relative rapid calibration of the X-ray beam used in medical applications;
b) they also allow an accurate calibration of the field instruments used by the service companies, when they have to repair and/or verify during, the current maintenance operations, the medical X-ray equipment.

Another important aspect of the measuring methods presented in this paper is that they allow to measured precisely both the high voltage, and the absorbed dose and the measuring time in the beam. When the measuring method for the intensity of the tube current will be elaborate, they will allow to measure the radiological yield of the tube (η=D/IU); this is a very important parameter of an X-ray equipment. When it's value become lower than a given value (usually 0.6) this means that the irradiation time must be increased, in order to obtain an accurate image; in this case, the irradiation of the patient growth, situation which can not be accepted. So, the X-ray tube must be replaced, or the whole equipment must be replaced by a new one.

ACKNOWLEDGEMENT

The activity which leaded to this paper was supported by the Ministry of Education, Research, Youth and Sport of Romania, in the frame of the project PN 09 37 02 05.

REFERENCES

[1] CEI/IEC 61267:2005 – Medical diagnostic CX-ray equipment-Radiation conditions for use in the determination of characteristics
[2] TRS 457 – Dosimetry in Diagnostic Radiology; An International Code of Practice
[3] Manual BARRACUDA

Author(s):
Mr. Bercea Sorin : Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH Bucharest); Department of Radionuclides and Radiation Metrology; 30 Reactorului St., Magurele, jud. Ilfov, P.O.B. MG-6, RO-077125, ROMANIA; bercea@nipne.ro; telephone:+4021.404.23.38; +40740102756
Mr. Cenusa Constantin: Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH Bucharest); Department of Radionuclides and Radiation Metrology ; 30 Reactorului St., Magurele, jud. Ilfov, P.O.B. MG-6, RO-077125, ROMANIA; constantin.cenusa@nipne.ro; telephone:+4021.404.23.38
Mrs. Celarel Aurelia: Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH Bucharest); Department of Radionuclides and Radiation Metrology; 30 Reactorului St., Magurele, jud. Ilfov, P.O.B. MG-6, RO-077125, ROMANIA; aurelia.celarel@nipne.ro; telephone:+4021.404.23.38